

# OK, now my favorite subject: RPCs in a shipping container

- **1200 custom 28 ft long modules replaced with 2400 standard 20 ft steel shipping containers**
  - \$ 3500 custom module becomes \$1000(used) or \$1500(new) container
    - Readily available throughout the U.S. (trade imbalance)
- **Full modules can be built and tested at many sites**
  - Nice for collaboration, but have to watch transportation costs

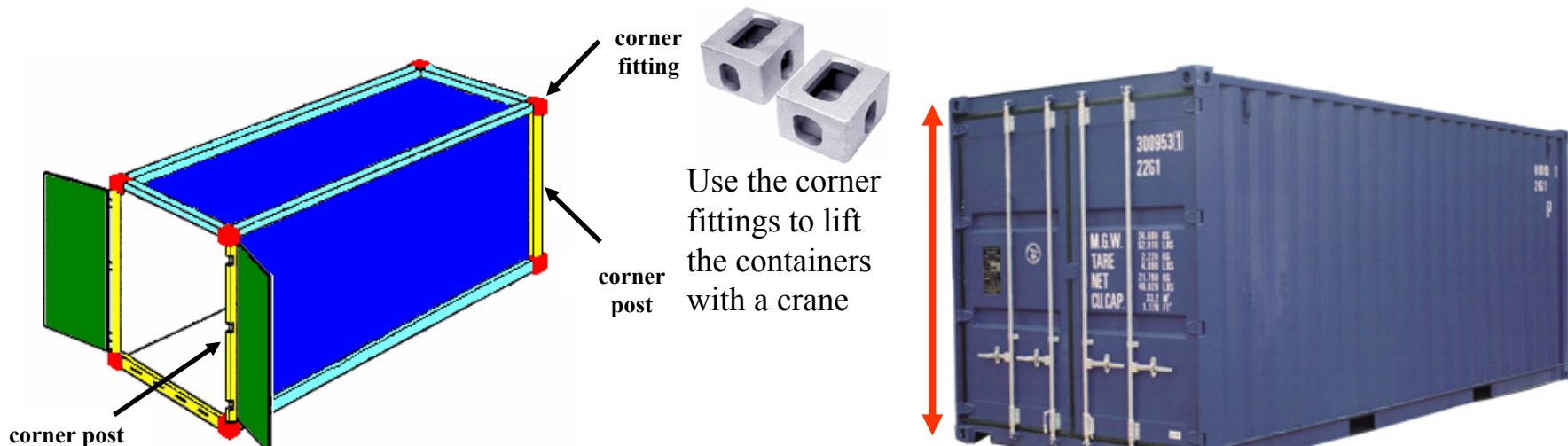


Figure 1. ISO Series 1 Shipping Container

8'6" high  
Work at human scale

# “The” Container Problem

- Standard ISO containers introduce a new problem

- there is 20 cm high dead space or “crack” at the bottom of the container for fork lift pockets and the container floor and another dead space at the door end of the container (thick door)
  - So 1.98% dead area →  
 $1.9 + 7.6 + 2.6 \% =$   
**12.1% dead area**



- Can software for a “Tracking” Calorimeter keep track of where each track passes through such cracks and compensate? Clearly has to be a more sophisticated algorithm than what we use in simulations today.

# BUT, Container Advantage #1

- A steel container does not rely on the strength of particle board absorber since the container has a fully supported floor – **Cheaper Absorber?**
  - Price of particle board is \$ 0.13 per pound and we need \$ 12.4 M of it
    - Radiation length is 53.6 cm, density is 0.65 gm/cc
  - An alternate material is Drywall or Sheetrock
    - This is Gypsum,  $\text{Ca SO}_4 \cdot 2\text{H}_2\text{O}$ , Calcium Sulfate Dihydrate
    - US annual output is 38,000 kilotons, Cost is about \$ 0.05 per pound
    - Radiation length is 37.9 cm, density is 0.68 gm/cc
  - Another alternate is Cellular Foam Concrete
    - This is Portland cement, sand, water, and “shaving cream”
      - 50% Tricalcium Silicate, 25% Dicalcium Silicate, 10% Tricalcium Aluminate, 10%Tetracalcium Aluminoferrite, all hydrated, 5% gypsum,
    - Not common in the US, invented in Europe, US price about \$ 0.10 per lb
    - Radiation length can be made at 47 cm with density of 0.7 gm/cc with sand : portland cement at 3.5 : 1, i.e “structural sand”
    - Pour in place, labor savings?

# Container Advantage #2

- ISO containers are designed for high stacks
  - at the US Interstate weight limit, they can be stacked as high as 12 on 1 with a safety factor of 1.48
    - See Off-Axis Note #8.
    - Some vendors make corner posts that could stack 13 on 1
  - This is 33.7 m or 110 ft high
- The detector building appears to be significantly cheaper (at equal volume) if higher but with a smaller footprint area.

# **Container Advantage #3 ...**

## **MOBILITY**

- Each institution can assemble full working modules
- We may not know the optimum site early?
- We may want to move to a different site after seeing a signal?

**20 ft unit on a standard ISO truck chassis**

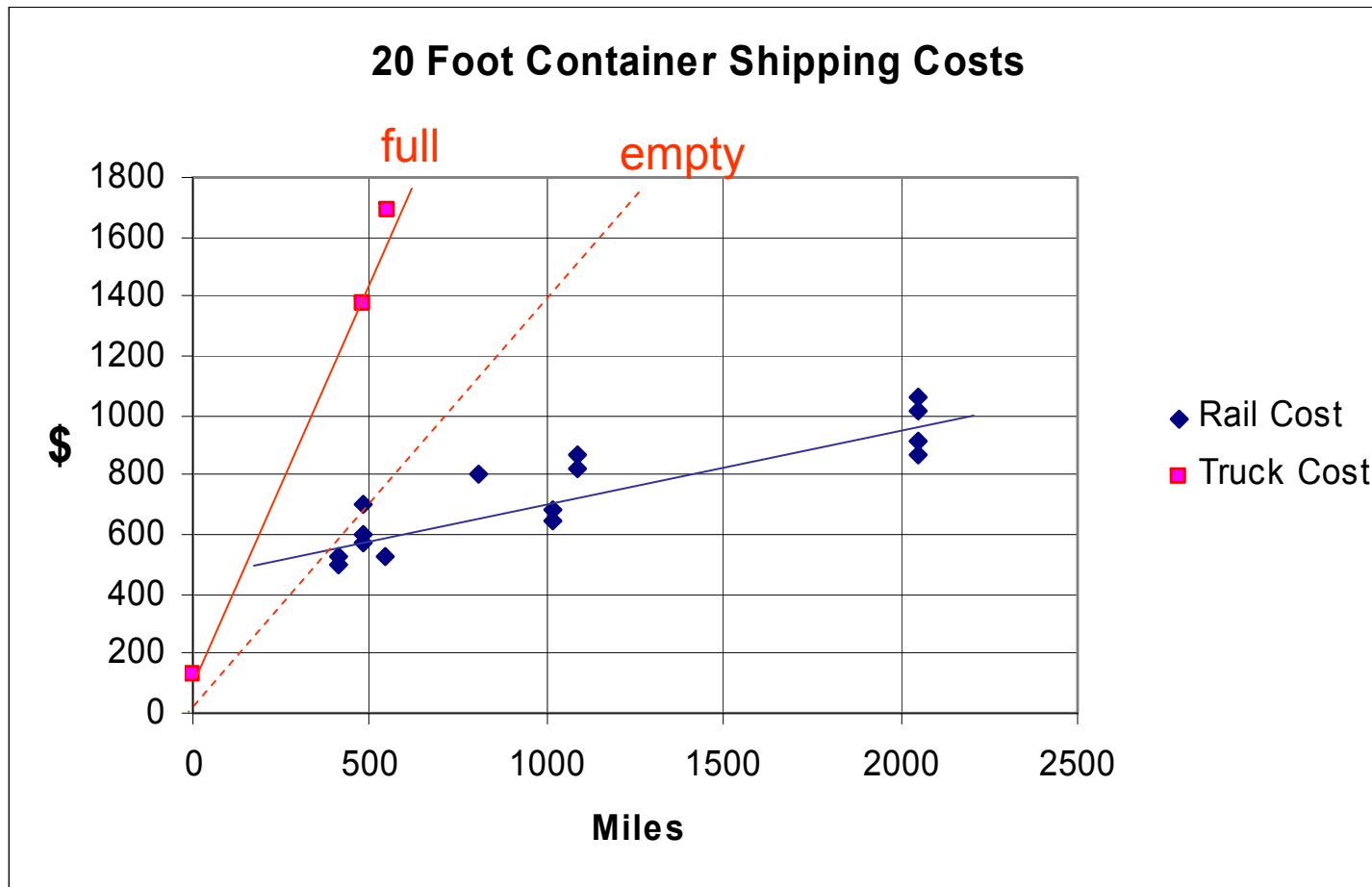


**Double Stack Rail car**



# Container Concern # 1

- must have a complete plan including correct transportation costs
  - US Interstate weight limit is a severe restriction
    - About 21.5 tons payload out of 40 ton maximum
    - > \$5,000 permits to go above this ?



# Container Concern #2

- What about access to HV, gas, electronics for those short ( 20-ft ) ISO containers?
  - At ANL in May I discussed “cell guides” (& they cost money)
  - The Toaster design leaves 5 cm in z between each stack just so that modules could be retrieved
    - » Can use this space for cables and gas
  - This seems like a good plan even if TWO stacks have to be removed for access to a module. **So, NO CELL GUIDES**

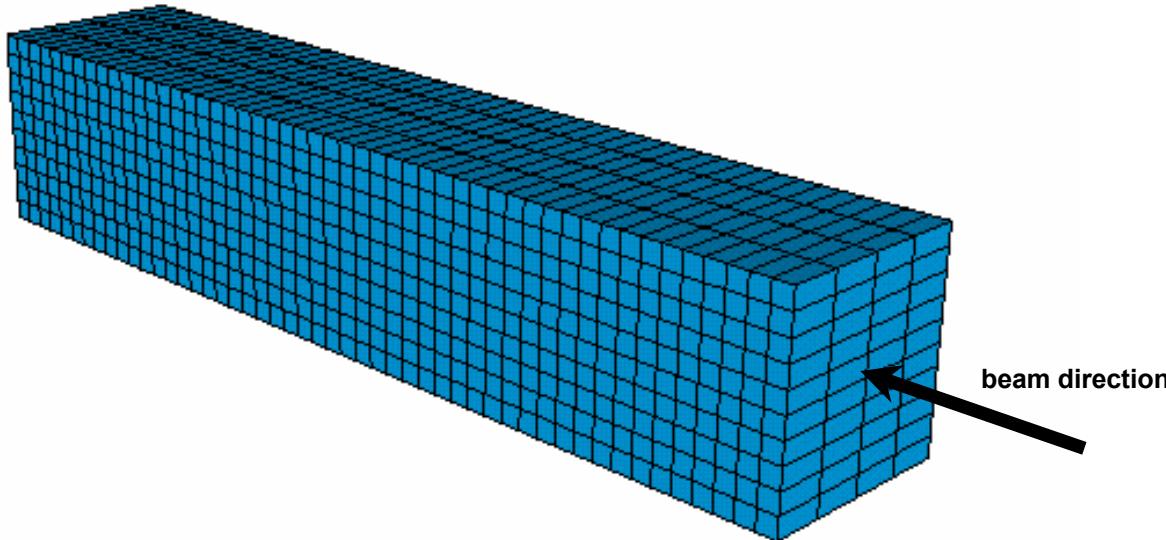


Figure 1. A 4x10x50 Container  
Array

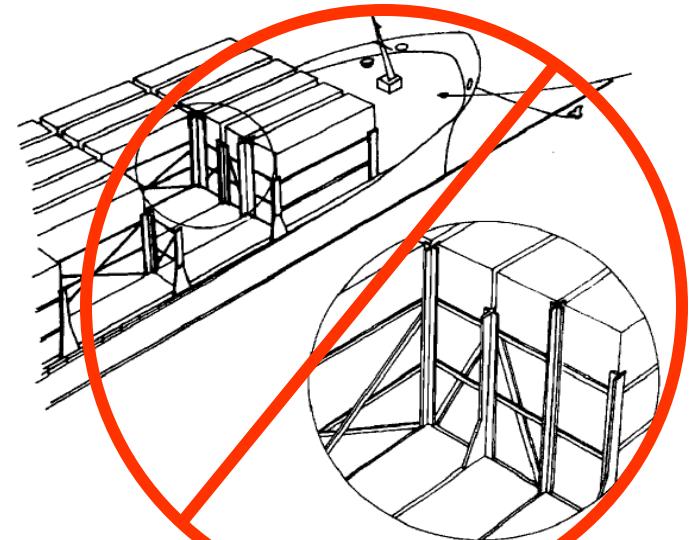
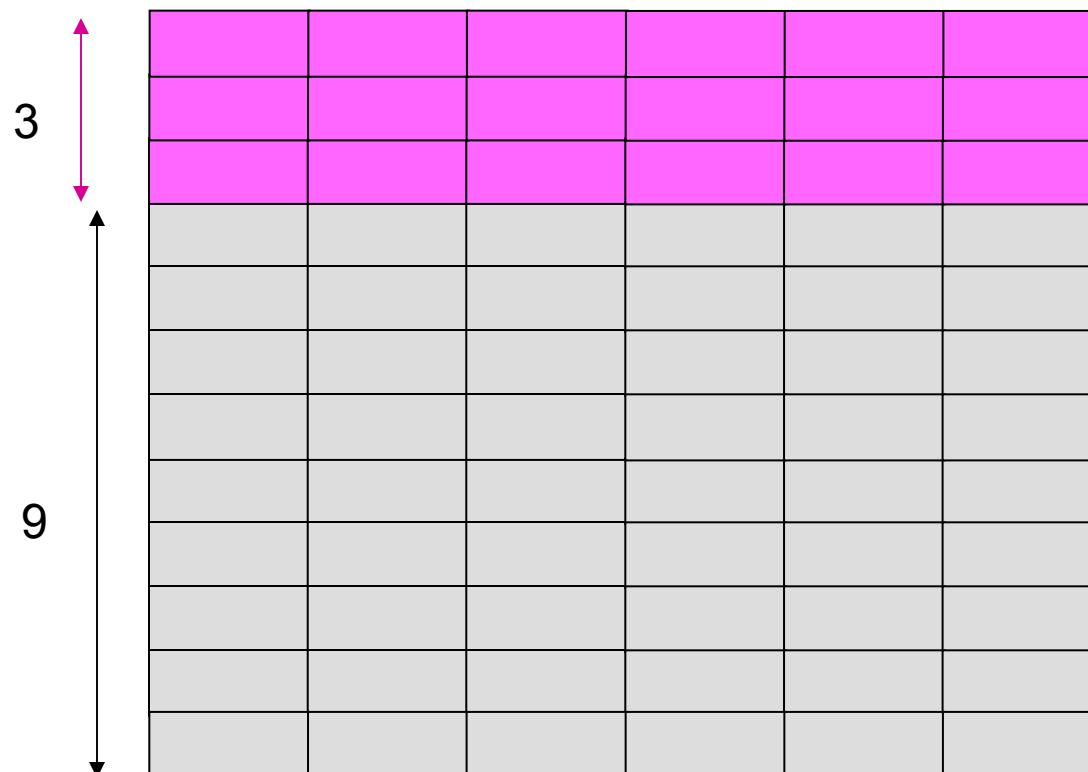


Figure 2. Container ship cell guides  
(from ISO Standards Handbook  
“Freight Containers”, Third Edition)

# Container Advantage #4

- IF we need an overburden, it can be more naturally handled in a container solution
  - Just fill top containers with absorber and use the high stacking capability

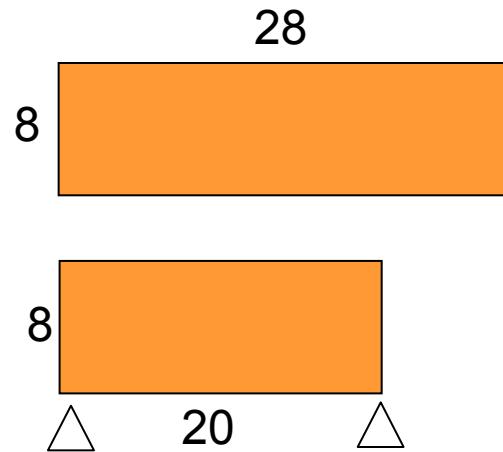
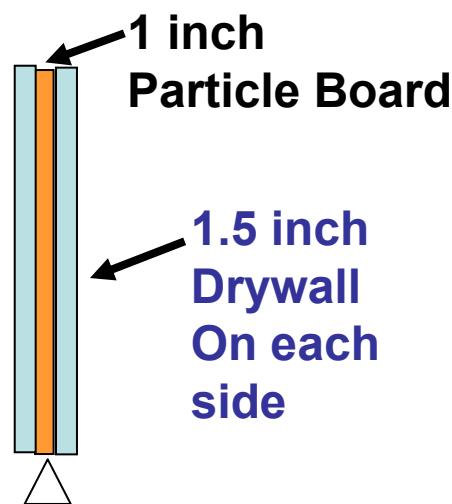


3 @ 0.7 g/cc  
= 0.875 @ 2.4 g/cc  
= 7 ft overburden

Similar argument  
For an active  
“veto” shield?

# If simulation shows ISO Containers are inefficient, is that the ballgame?

- No, depends on cost and performance
  - The question is: just how inefficient are they ?
- No, might cheaply modify containers
  - towards the current toaster design by ripping the floors out and installing a ledge
  - Still could use gypsum, attach to one 8 x 20 ft particle board



The particle board acts as a beam and holds 4 times its own weight

If limit the bearing stress to 150 psi (typical working #), A 28 ft span is problematic, But a 20 ft span is comfortable On a 8 inch ledge

# Container Summary

- **Container Advantages**

- ISO Containers are cheaper than a custom design
- The container floor can support a cheaper absorber
- Containers stack >100 ft high
  - building is cheaper
  - High stacks offer a natural way to handle an overburden if required
- Containers are mobile
  - Collaborative advantage during construction
  - Perhaps an advantage if the physics leads us to a new position

- **Container Problem**

- Can we live with larger cracks?

- **Container Concerns**

- We must understand the transportation costs in a complete model of detector assembly
- Electronics buried, must be reliable (better be reliable anyway !)
  - But it is possible to unstack and replace problems